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RESIDENTIAL & COMMERCIAL ENERGY MANAGEMENT

PROJECT NUMBER 8601

COMPARATIVE HEATING SYSTEM STUDY IN COOPERATIVE HOUSING DEVELOPMENTS

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COMPARATIVE HEATING SYSTEM STUDY
IN COOPERATIVE HOUSING DEVELOPMENTS

SYNOPSIS: In recent years, the natural gas industry has expressed concern over an apparent loss of natural gas heating loads to electric baseboard heating in Canada Mortgage & Housing Corporation-sponsored projects.

To investigate this theory, B. C. Hydro selected three cooperative housing complexes with different heating systems - one electric baseboard, one natural gas hydronic (hot water) and one natural gas forced warm air - and analyzed the performance of each system.

Using life cycle costing analyses, natural gas forced warm air proved to be the least expensive to own and operate, with electric baseboard second and natural gas hydronic the most expensive.

This report summarizes the results of these investigations. Although it is based on cooperative housing developments, the comparisons are applicable to other similar forms of housing.

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SUMMARY

The Canada Mortgage and Housing Corporation provides financial assistance for persons having difficulty finding affordable or suitable housing, through federal programs such as the Cooperative Housing Program.

In recent years, the natural gas industry has voiced concern over an apparent trend towards installation of electric baseboard heating in preference to natural gas systems for CMHC-sponsored housing projects. The contention is that, in most cases, electric heating is less costly to install than natural gas but more expensive to operate, resulting in excessive long-term energy costs and increased federal subsidies.

In an attempt to confirm or reject this theory, B. C. Hydro has conducted a study of three similar CMHC townhouse complexes located in Vancouver, one heated by natural gas forced warm air (furnaces), one by natural gas hydronic (boilers), and one by electric baseboard heaters. Actual energy consumption was compiled from B. C. Hydro files and was compared with energy usage predicted by in-house computer programs. A total of 147 townhouse units were included in this study.

Actual combined space heating and domestic water heating energy consumption was very close to the estimated amount for both the natural gas warm air and electric baseboard heated complexes. However, for the natural gas hydronic complex, actual consumption was approximately one-third higher than the estimated value.

Heating equipment cost estimates and anticipated service life were combined with energy cost and consumption data, to perform life cycle costing analyses comparing all three heating systems.

In terms of operating costs only, the electric baseboard system was indeed the most costly, with natural gas hydronic second and natural gas warm air having the lowest operating cost.

Using the more detailed and meaningful life cycle costing analysis, natural gas warm air remained the least expensive system to own and operate, while electric baseboard became second and natural gas hydronic was most expensive, mainly due to higher initial equipment investment.

Sensitivity analyses indicated that, at very high assumed fuel price escalation rates (14% - 16% per annum), the hydronic system became less costly than electric baseboard heating. Forced warm air retained its economic advantage over the other systems for all life cycle costing situations investigated.

It was also determined that when service connection charges are added to in-house equipment costs, an electric baseboard system can be more expensive to install than a gas forced warm air system.

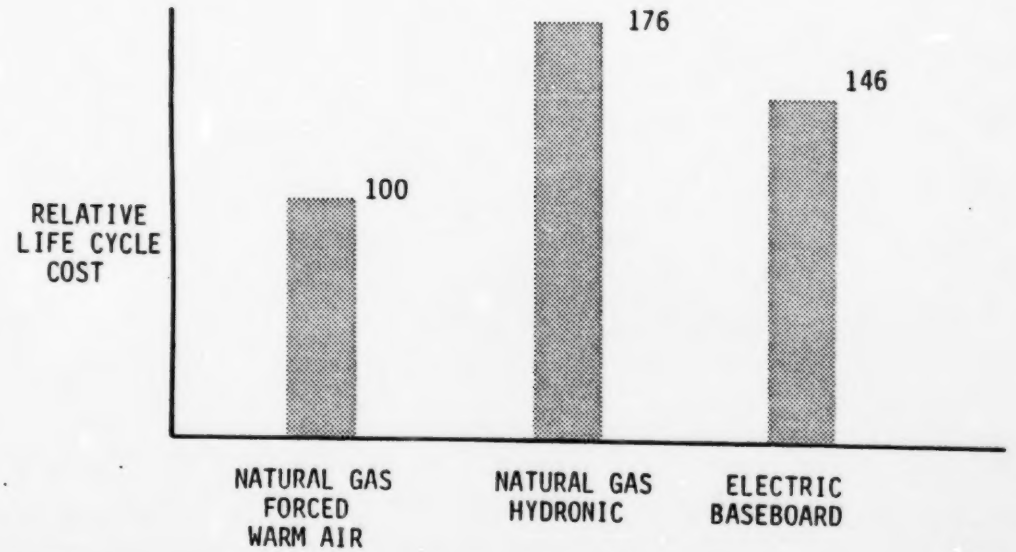
Based on an average 102 m² (1100 ft²) townhouse unit, actual space and water heating energy consumption data, and B. C. Hydro residential energy rates, the following comparisons exist for the natural gas forced warm air, natural gas hydronic, and electric baseboard complexes investigated.

COMBINED SPACE HEATING AND DOMESTIC WATER HEATING
SYSTEM COST COMPARISON

Heating Systems	Capital Costs			Operating Cost	Life Cycle Cost
	Equipment $/Unit	Service Connection $/Unit	Total $/Unit	$/Unit/Yr	$/Unit/25 Yrs
Natural Gas Forced Warm Air; Gas Water Heater	2125	5	2130	290	6800
Natural Gas Hydronic; Gas Water Heater	4823	7	4830	400	12000
Electric Baseboard; Electric Water Heater	1980	370	2350	475	9900

Although this report is based on cooperative housing developments, the analysis procedure and relative comparisons are applicable to other similar forms of housing.

LIFE CYCLE COST COMPARISON



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INTRODUCTION

The Canadian Gas Association, which represents members from all sectors of the natural gas industry in Canada, has expressed concern about the loss of natural gas loads to electric baseboard heating in Canada Mortgage and Housing Corporation-funded cooperative housing projects.

CMHC provides various forms of assistance to groups which can demonstrate the need for a particular type of housing within the community. It is during the review period between project inception and final design that the heating system concept is frequently altered, as a result of the following process:

Canada Mortgage and Housing Corporation allocates a fixed sum of money for each specific housing project, following a detailed selection process in which the merits of the application are carefully scrutinized. To encourage the production of modest housing, maximum unit prices are established for each type of housing, depending upon the region. These maximum prices cannot be exceeded except in special cases such as in facilities for the physically handicapped, where special provisions may apply. Historically, this fixed sum has been very close to the estimated cost of construction.

The Cooperative Board of Directors, which controls the dissemination of these funds, also decides upon the preferred type of heating system. In many cases, after the funds are apportioned and tenders for each phase of the work are received, the project cannot be completed as designed, within the budgeted amount. Consequently, cost-cutting measures are employed by the Contractor and the cooperative members, which often include replacement of the natural gas system with perceived lower-first-cost but more-expensive-to-operate electric baseboard heaters.

Since both capital and operating costs for CMHC-sponsored cooperative housing projects are government subsidized through a series of complex funding formulas, it is in the best interest of taxpayers and housing project tenants alike to reduce heating costs wherever possible. The purpose of this report is to investigate the predicted long-term financial effects of cooperative housing heating system selection, based on both actual data and calculated heat loss and energy consumption analyses.

Although each type of heating involved in the study has its relative advantages and disadvantages, this report is strictly an economic comparison, and does not focus on these aspects of the systems.

PROCEDURE AND RESULTS

Housing Complex Selection

At the outset of this project, a number of row and townhouse complexes with different types of heating systems were investigated. Discussions were held with B. C. Hydro service planners, architectural firms, contractors and CMHC personnel during the process of identifying typical townhouse complexes suitable for study. Final housing project selection was based upon the following requirements.

(a) Metering

Individual energy consumption metering for each dwelling must be available. This prerequisite meant that areas such as service buildings, laundry rooms and centrally heated apartment buildings were excluded from consideration.

(b) Location

Complexes should be within close proximity of each other, minimizing the possibility of localized atmospheric conditions and subsequent non-uniform heating system usage.

They must also be located in B. C. Hydro's gas and electric service area, to facilitate access to energy consumption data.

(c) Construction Period

Construction should be within roughly the same time period, lessening the effects of technology, building materials and procedures, and prevailing economic conditions.

(d) Unit Types

In order to compare the performance of all heating systems on a common basis, only side-by-side townhouse units were selected. Apartment buildings, service buildings, and up/down townhouse units were subsequently excluded.

(e) Available Data

A minimum of two heating seasons' worth of data for each complex must be available. This allows for one season of relatively high energy consumption while the newly constructed building is drying out, and a second season of more typical consumption. Only data from the second of two heating seasons was used in preparing this report.

Applying these criteria, three CMHC-sponsored housing projects, all located within the Champlain Heights area of Vancouver, British

Columbia, were selected. Each complex is briefly described in the following table.

COOPERATIVE HOUSING COMPLEX
GENERAL INFORMATION

Complex	Heating System	Insulation Values (Ceiling/Walls)	Number of Units
1	Gas Furnace	RSI 5.4/RSI 3.5 (R30/R20)	65
2	Gas Boiler	RSI 4.9/RSI 2.1 (R28/R12)	50
3	Electric Baseboard	RSI 4.9/RSI 3.5 (R28/R20)	32

Table 1

A more detailed description including typical housing unit floor plans can be found in Appendix A.

Heating Season

The heating season selected for this study was from 1 January 1985 to 31 December 1985. Approximately ten months' additional heating data was available, but it was considered unreliable due to the drying-out period previously discussed.

Energy Consumption

(a) Actual Energy Consumption

"Actual Space Heating and Domestic Hot Water Heating Energy Consumption", which represents the area weighted average energy consumption for all residents within each townhouse complex, is contained in Tables B-1, B-2, and B-3 of Appendix B.

This information was generated by using B. C. Hydro's Building Energy Analysis System (BEAS). The program transfers energy consumption data from the billing system into a file created for each selected account, and combines it with building data and degree day information to generate various types of reports. The Commercial Building Data Base Program is one part of this system. A short description of this program and building information data sheet EC 413 is attached as Appendix C.

For all cases, whether electric or gas, it was impossible to accurately differentiate between energy consumption attributable to space heating and that used for domestic hot water production. Therefore, combined space and domestic water heating energy consumption figures are used throughout the report, and are occasionally abbreviated as "SH + DHW" in the tables.

(b) Estimated Energy Consumption

"Estimated Space Heating and Domestic Hot Water Heating Energy Consumption", and "Estimated Heat Loss" data is also summarized in Tables B-1, B-2 and B-3 of Appendix B.

These figures were calculated using B. C. Hydro's Residential and Commercial Energy Advice Program H10. This program, developed by Residential and Commercial Energy Management, provides customers with advice and recommendations on equipment sizing, annual heating costs, insulation levels, and fuel conversion. A copy of the program questionnaire and sample print-outs are attached as Appendix D.

Also included in Appendix D are examples of various data sheets, dealing with similar subject material, produced by B. C. Hydro Residential and Commercial Energy Management.

Floor dimensions, window and door areas and methods of construction, and insulation values for all housing components were obtained from townhouse complex construction drawings, and were used as input data for program H10. A typical example of the program output is illustrated on pages D-2 and D-3 of Appendix D.

The resulting heat loss, space heating, and water heating energy consumption estimates were combined with numbers of townhouse units and floor areas to produce "average per square metre" estimated heat loss and energy consumption data, as shown in Tables B-1, B-2, and B-3 of Appendix B.

Similar "consumption per unit area" averages were calculated using actual energy consumption data, and are likewise included in Tables B-1, B-2 and B-3.

Heat loss estimates generated by program H10 (for example, page D-2, Appendix D) are used as a guide for sizing building heating equipment, and are included in this report for information only.

Both actual and estimated energy consumption for each housing complex are summarized in Table 2, as follows:

ENERGY CONSUMPTION - SPACE HEATING AND DOMESTIC WATER HEATING

COMPLEX	HEATING SYSTEM	ESTIMATED	ACTUAL	% VARIATION
1	Gas Furnaces	0.5858 $\frac{GJ}{m^2yr}$	0.5220 $\frac{GJ}{m^2yr}$	-11
2	Gas Boilers	0.5873 $\frac{GJ}{m^2yr}$	0.7757 $\frac{GJ}{m^2yr}$	+32
3	Electric Baseboard	99.58 $\frac{kW.h}{m^2yr}$	103.66 $\frac{kW.h}{m^2yr}$	+4

Table 2

The purpose of generating "estimated energy consumption data" was to provide an indication of how well each heating system performed in relation to what past experience and theoretical calculations predicted. This technique would also forewarn the investigator of a possible irregularity in the collected data or a major system deficiency.

For the electric baseboard case, the computer program assumes that the user will take advantage of the flexibility of the system and heat individual rooms only as required. This results in an approximate 6% reduction in estimated energy consumption using room-by-room heating. If this practice is not followed, the "estimated energy consumption" would probably be about 6% higher, or 105 kW.h/m² yr.

Since the townhouse units are fairly small, there is less likelihood of effective room-by-room control. Therefore the higher estimated energy consumption figure of 105 kW.h/m² yr is probably more accurate than the tabulated value of 99.58 kW.h/m² yr, and is closer to agreement with the actual energy consumption of 103.66 kW.h/m² yr.

Natural gas forced warm air and hydronic systems are assumed to have a 65% seasonal operating efficiency. However, a newer system is usually capable of higher efficiencies, which may explain why the gas furnace complex has a lower actual energy consumption than estimated. Conversely, the hydronic system used more energy than predicted, which could be due to system irregularities or may simply be attributable to lifestyle. This subject is discussed in greater detail in the Analysis, beginning on page 11.

Capital Costs

Capital costs for space heating and domestic water heating equipment were estimated by B. C. Hydro personnel using direct material take offs from drawings of each townhouse complex. All costs are in 1986 dollars and include materials and labour.

It was considered that in-house equipment cost estimates would be utilized because of the difficulty in obtaining accurate project cost breakdowns, and the uncertainty involved in translating those costs to present-day figures.

Another item which has been included as a capital cost directly attributable to the heating system on a "per unit" basis was the service connection. This is the charge, payable by the developer, for equipment and service necessary for connection to the utility company's gas or electric system, which in this case is B. C. Hydro.

Apportionment of these service connections is more fully described in item 2 of the Analysis, page 12.

Capital costs are summarized below, based on an average 102.2 m² (1100 ft²) townhouse unit.

CAPITAL COSTS - SPACE HEATING AND DOMESTIC WATER HEATING

COMPLEX	HEATING SYSTEM	EQUIPMENT $/UNIT	SERVICE CONNECTION $/UNIT	TOTAL $/UNIT
1	Gas Furnace	2125	5	2130
2	Gas Boiler	4823	7	4830
3	Electric Baseboard	1980	370	2350

Table 3

Operating Costs

Heating system operating costs listed in Table 4, below, were based upon current B. C. Hydro energy rates, outlined in Appendix E. These figures represent the cost of energy only; equipment replacement and maintenance over the lifetime of the project is taken into account in the Life Cycle Costing analysis which follows this section. Operating costs are presented for both the estimated and actual energy consumption cases. These figures are also based on an average 102.2 m² (1100 ft²) townhouse unit.

OPERATING COSTS - SPACE HEATING AND DOMESTIC WATER HEATING

COMPLEX	HEATING SYSTEM	ESTIMATED $/UNIT/YR	ACTUAL $/UNIT/YR	% VARIATION
1	Gas Furnace	316	287	-9*
2	Gas Boiler	316	400	+27*
3	Electric Baseboard	455	474	+4**

Table 4

* Does not agree with % variation from Table 2, page 7, because annual operating costs for natural gas systems include B. C. Hydro's Basic Charge of $9.28 per period (refer to Appendix E).
** Corresponds with % variation in Table 2, since the Basic Charge has been attributed to the "lighting and miscellaneous" portion of total electrical costs.

Life Cycle Costing

(a) Heating System Cost Comparison

To provide a more comprehensive and meaningful method of comparing the various heating systems, a life cycle costing analysis was performed, again assuming a 102.2 m^2 (1100 ft^2) townhouse.

Life cycle costing takes into account economic variables such as capital and operating costs, maintenance costs and equipment replacement, interest rates, energy costs and inflation rates, over the lifetime of a particular project. Although they are of interest, capital and/or operating costs alone cannot fully portray the economic advantages of one system over another.

Life cycle costing is more fully described in Appendix F.

Table 5 illustrates the results of this procedure for both actual and estimated energy consumption rates, based on the following assumptions:

- Life of Project = 25 years
- Borrowing Rate = 10%
- Interest Rate = 9%
- Inflation Rate = 5%
- Fuel Escalation Rate = 6%
- Equipment Service Life = 25 years
- Equipment Salvage Value = 5%
- Typical 102.2 m^2 Townhouse
- All costing in $1986
- Current B. C. Hydro Residential Energy Rates (Appendix E)

COMPLEX	HEATING SYSTEM	ESTIMATED ENERGY CONSUMPTION RATES LIFE CYCLE COST, $/25 YEARS	ESTIMATED ENERGY CONSUMPTION RATES RELATIVE LIFE CYCLE COST	ACTUAL ENERGY CONSUMPTION RATES LIFE CYCLE COST* $/25 YEARS	ACTUAL ENERGY CONSUMPTION RATES RELATIVE LIFE CYCLE COST
1	Gas Furnace	7,300	100	6,800	100
2	Gas Boiler	10,600	145	12,000	176
3	Electric Baseboard	9,600	132	9,900	146

Table 5

* Represents the equivalent cash required, at the present time, to own and operate the system over the lifetime of the project.

Since Complex #1 exhibited the lowest life cycle cost for both energy consumption rates, it was assigned a value of 100 and was used as the standard against which Complexes #2 and #3 were measured.

(b) Effect of Equipment Service Life

An important factor in the life cycle costing process is equipment service life, or the interval at which expenditures for replacement equipment must be inserted into the calculations.

Life cycle cost analyses were repeated using three different sets of equipment service life assumptions, a summary of which also appears on page F-2 of Appendix F.

For this report, a uniform equipment service life of 25 years for each system has been employed, as the information preceding Table 5 indicates.

(c) Effect of Varying Interest and Fuel Escalation Rates

Life cycle costing is also dependent upon interest rates and variations in the cost of fuel and equipment.

To determine the sensitivity of the life cycle costing technique to these factors, calculations were repeated for all three heating systems, using various fuel escalation rates while all other variables remained constant. The results of this procedure are presented on page F-3 of Appendix F.

Effect of Insulation

A review of Tables 1 and 4 indicates that housing Complex #1 had the highest insulation levels and lowest operating cost in terms of fuel consumption. Once this relationship had been established, "hypothetical" fuel consumption analyses for Complexes #2 and #3 were generated. These "modified actual" cases represented the energy consumption for the natural gas hydronic and electronic baseboard complexes, had they been insulated to Complex #1 standards, as tabulated below.

COMPLEX	HEATING SYSTEM	ENERGY CONSUMPTION		
		ACTUAL	MODIFIED ACTUAL	% DIFFERENCE
1	Gas Furnace	0.5220 $\frac{GJ}{m^2yr}$	0.5220 $\frac{GJ}{m^2yr}$	0
2	Gas Boiler	0.7757 $\frac{GJ}{m^2yr}$	0.7552 $\frac{GJ}{m^2yr}$	-2.6
3	Electric Baseboard	103.66 $\frac{kW.h}{m^2yr}$	103.48 $\frac{kW.h}{m^2yr}$	-0.2

Table 6

Tables G-1 and G-2 of Appendix G contain the "modified actual" results for Complexes #2 and #3.

ANALYSIS

1. Domestic Water Heating

As previously discussed, it was impossible to separate the quantity of energy required for space heating from that used in domestic hot water production, since the energy commodity is measured through a common meter.

Although space heating requirements are fairly predictable, hot water usage, which can account for 50% or more of the total combined heating system consumption, is far more variable depending upon numbers of people and their particular lifestyles. It is expected that a large portion of the difference between "Actual" and "Estimated SH&DHW consumption" is due to the uncertainty of hot water usage prediction.

In an attempt to minimize this effect, actual numbers of residents were used in calculations wherever possible.

The use of energy consumption figures expressed in terms of combined space heating and domestic water heating is not expected to impose a major limitation on the usefulness of the data, however, since common systems are normally installed in tandem, for new installations.

2. Service Connections

Tables 3 and A-1 of Appendix A indicate the cost of utility company service connections, for both gas and electric services. Since Complex #2 used no electric heating whatsoever, its electrical service connection was attributed to "lighting and miscellaneous" only. For Complex #3, the all-electric case, the difference in the service connection per unit and that of Complex #2 was considered to be the premium paid for electric baseboard heater installation. Although previous studies have addressed possible additional costs to other in-house electrical system components as a result of electric baseboard heater installation, this report considers the service connection premium only.

3. Heating System Irregularities

Table 2 indicates that the natural gas hydronic system complex consumed 32% more energy than the amount calculated by Residential Energy Advice Program H10.

It is beyond the scope of this report to speculate as to why this occurred, however, hydronic heating system difficulties in general can arise from:

- poorly insulated hot water piping;
- system design problems such as improper zoning or oversized equipment.

Since the hydronic system is more complex to design and operate, it has the potential to waste more energy than other systems.

CONCLUSIONS

1. As anticipated, both the natural gas furnace and natural gas boiler-heated complexes were less costly to operate than the electric baseboard-heated complex. However, the gas furnace unit used 11% less energy than estimated, the gas boiler unit used 32% more than estimated, while the electrically-heated unit consumed about 4% more energy than estimated.

2. A life cycle costing analysis of the three heating systems indicates that natural gas furnaces are the most economical to own and operate, while electric baseboards are second and natural gas hydronic systems are the most expensive. Since this analysis covers all aspects of costing, it is the most accurate form of comparison.

3. A review of the effects of equipment service life on life cycle costing indicated that for the heating systems investigated, the absolute life cycle costs were modified, but the order of appearance in terms of economic advantage remained the same.

4. Sensitivity analyses indicated that, as fuel escalation rates increased, life cycle costing became more influenced by operating costs, until the gas hydronic system was cheaper to own and operate than the electric baseboard system. An increase in interest and borrowing rates shifted the analysis in favor of the lower-capital-cost forced warm air system. Again, the forced warm air heating system was least expensive under all conditions.

5. A study of the effects of "reinsulating" Complexes #2 and #3 to Complex #1 standards resulted in an insignificant reduction in energy consumption, indicating that all three complexes are satisfactorily insulated.

6. When service connection charges resulting from the addition of electric baseboard heating are added to the in-house equipment cost, electric heating can be more expensive to install than natural gas systems.

RECOMMENDATIONS

This study involved 147 townhouse units in three separate CMHC-financed housing projects. Ideally, information from a more extensive number of complexes and units would be desirable, resulting in a larger data base.

Since the natural gas hydronic system exhibited the largest variance between actual and estimated energy consumption, it is recommended that the performance of at least one additional hydronic system complex should be investigated. It would be useful to determine whether or not such variance is an anomaly, or the norm for hydronic systems in this particular application.

It should be emphasized that each of the heating systems discussed has its relative advantages and disadvantages, and that in many cases, the heating system type will not be selected on the basis of capital and/or operating cost alone.

However, analyzing the report from the standpoint of publicly-subsidized housing, it is clear that electrically-heated townhouses are more expensive to heat than natural gas-fired units, and the following recommendations can be made:

1. that CMHC, during the project review stage, require the cooperative to perform a projected heat loss and fuel consumption study as part of the approval process.

2. that CMHC consider offering a strictly dedicated bonus, above and beyond the normal maximum unit price, to cover a legitimate and proven extra cost for a preferred heating system which demonstrates a definite long-term economic advantage. A Life Cycle Costing Analysis is recommended for this purpose.

APPENDIX A

Cooperative Housing Complex

General Information

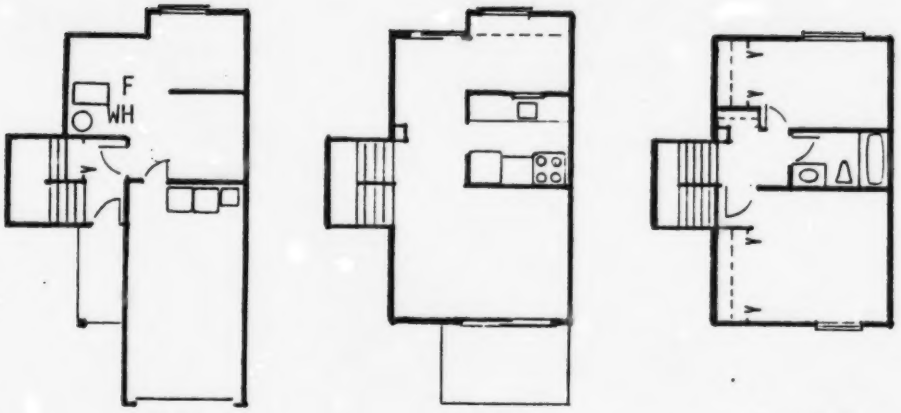
TABLE A-1
COOPERATIVE HOUSING COMPLEX
GENERAL INFORMATION

	COMPLEX NUMBER	1	2	3
1	HEATING SYSTEMS			
	a Space Heating (SH)	Individual Gas Furnaces	Individual Gas Boilers	Electric Baseboard Heaters
	b Water Heating (DWH)	Individual Gas-Fired Water Heaters	Individual Gas-Fired Water Heaters	Individual Electric Water Heaters
2	NUMBER OF TOWNHOUSE UNITS			
	a 2-Bedroom	30	15	36
	b 3-Bedroom	27	31	24
	c 4-Bedroom	8	4	-
	Total	65	50	60**
3	YEAR OF CONSTRUCTION	1982	1984	1984
4	INSULATION VALUES			
	a Ceiling	RSI 5.4 (R30)	RSI 4.9 (R28)	RSI 4.9 (R28)
	b Above Grade Walls	RSI 3.5 (R20)	RSI 2.1 (R12)	RSI 3.5 (R20)
	c Windows	Double Glazed ¼" Air Space	Double Glazed ¼" Air Space	Double Glazed ¼" Air Space
	d Doors	Steel;Polyurethane Core	Wood;1½" Solid	Steel;Polyurethane Core
5	SERVICE CONNECTIONS			
	a Electric:			
	Description:	Single Phase 6 Transformer Kiosks	Single Phase 3 Transformer Kiosks	Three Phase
	Cost:	$23,600*	$11,000	$35,100
	Cost/Unit:	NA	$220	$585
	b Gas:			
	Cost:	$350	$370	-
	Cost/Unit:	$5	$7	-

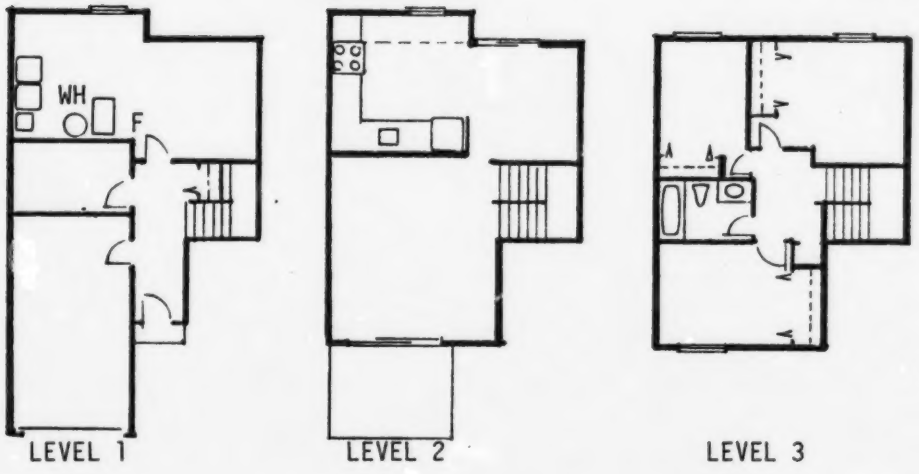
* This housing complex also contains 12 all-electric apartment units, (not part of this study), adding to the cost of the electric service connection.

** Only 32 of these units have been used to determine heat loss and energy consumption figures shown on Tables B-3 of Appendix B and H-2 of Appendix H. Twenty-eight of the units are in an up/down configuration, while the study is based upon heating system performance in side-by-side townhouses.

COMPLEX #1
TYPICAL FLOOR PLANS



TWO BEDROOM UNIT

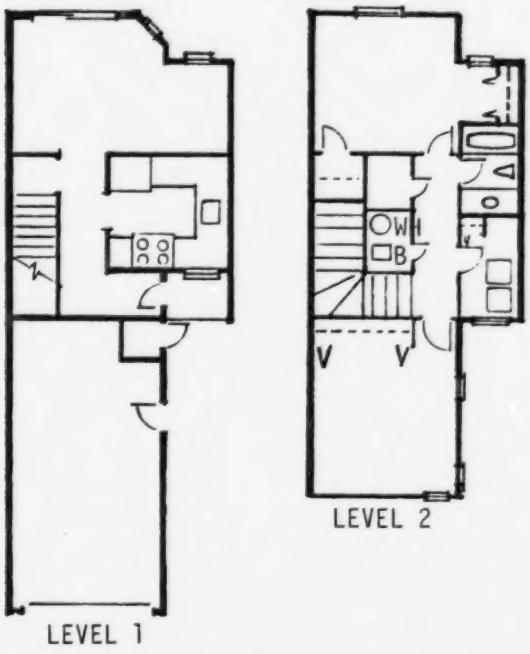


THREE BEDROOM UNIT

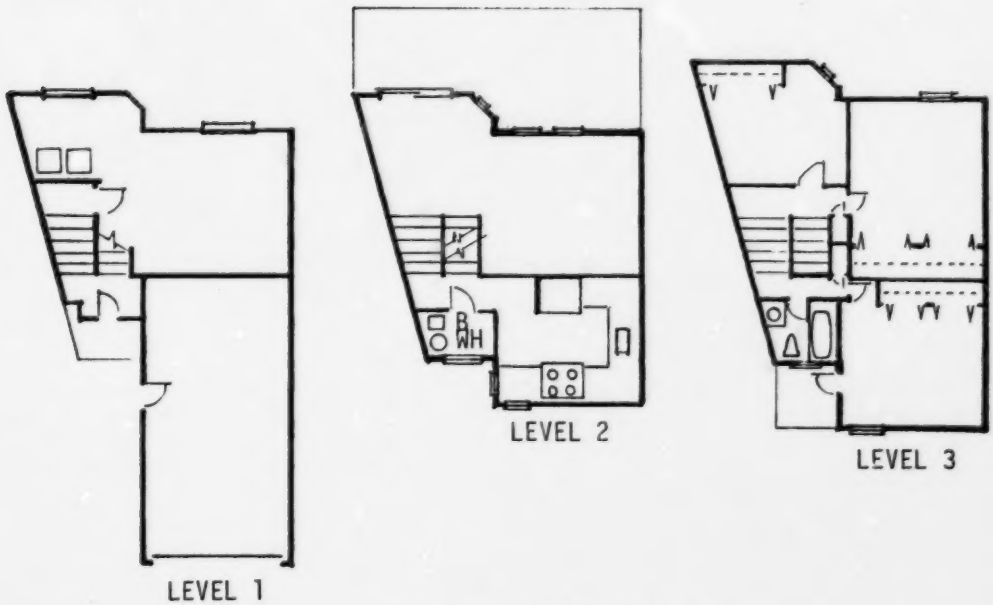
F = Gas Furnace
WH = Gas Water Heater

A-3

COMPLEX #2
TYPICAL FLOOR PLANS



TWO BEDROOM UNIT



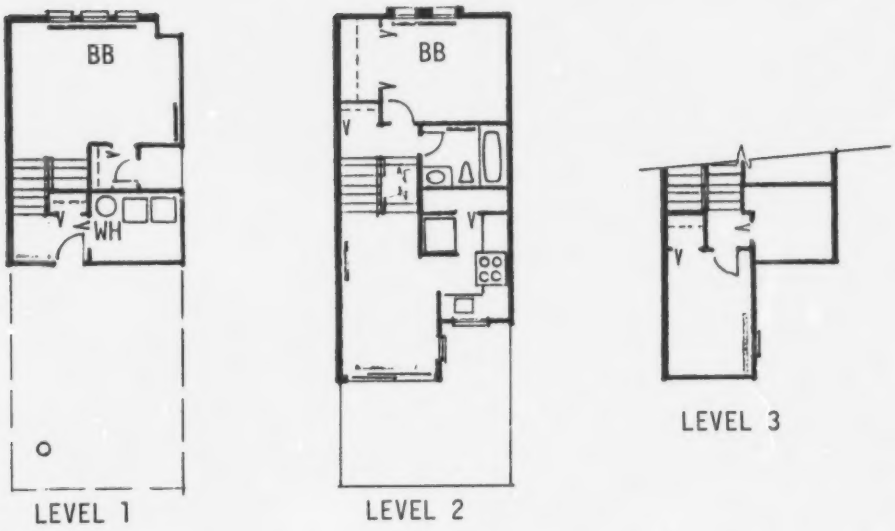
THREE BEDROOM UNIT

B = Gas Boiler

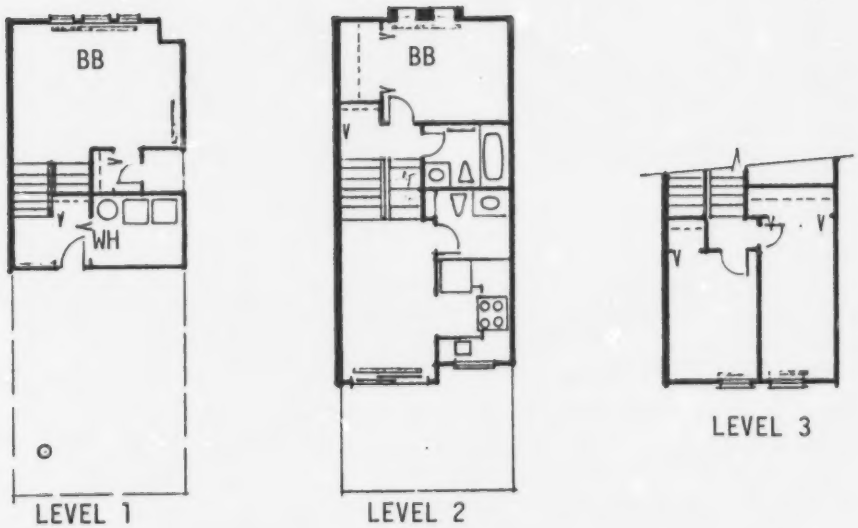
WH = Gas Water Heater

A-4

COMPLEX #3
TYPICAL FLOOR PLANS



TWO BEDROOM UNIT



BB = Electric Baseboard Heater
WH = Electric Water Heater

A-5

COMPLEX #1

NATURAL GAS FORCED WARM AIR SYSTEM

COMPLEX #2
NATURAL GAS HYDRONIC SYSTEM

A-7

COMPLEX #3
ELECTRIC BASEBOARD SYSTEM

APPENDIX B

Cooperative Housing Complex

Heating System Performance and Capital Cost Data

COMPLEX #1 - NATURAL GAS FORCED WARM AIR SYSTEM

Project Name: Cooperative Housing Heating Study
Complex #1-Natural Gas Forced Warm Air Heating - Actual Case

Unit Type	No. of Units	Floor Area Per Unit		No. of Bed-rooms	Estimated Heat Loss		Estimated Consumption			Actual SH & DHW	Capital Cost Estimates		
							Space Heating	DHW Heating	SH & DHW Heating	Energy Cons.	Space Heating	DHW Heating	SH & DHW Heating
		sq.m.	sq.ft.		kW	Btu/h	GJ	GJ	GJ	GJ	$	$	$
A	8	103.6	1115	2	5.9	20089	39.9	24.7	64.6	54.1	2019	350	2369
B	8	126.3	1360	3	6.6	22420	44.5	30.9	75.4	66.0	2139	350	2489
C	8	142.0	1528	4	7.3	24962	52.6	37.2	89.8	74.1	2219	350	2569
D	10	95.7	1030	2	5.1	17480	33.2	24.7	57.9	50.0	2059	350	2409
E	5	95.7	1030	2	5.5	18817	35.4	24.7	60.1	50.0	2059	350	2409
F	10	115.3	1241	3	5.9	20125	37.9	30.9	68.8	60.2	2099	350	2449
G	5	115.3	1241	3	6.3	21485	42.5	30.9	73.4	60.2	2099	350	2449
H	7	121.4	1307	2	4.8	16367	31.9	24.7	56.6	63.4	1979	350	2329
J	4	153.9	1657	3	6.2	21007	40.6	30.9	71.5	80.4	2019	350	2369
Gross Totals:	65	7605.5	81866	173	385.7	1315925	2582.2	1872.9	4455.1	3970.5	135315	22750	158065
Average Per Unit:		117.0	1259	2.7	5.9	20245	39.7	28.8	68.5	61.1	2082	350	2432
Average Per sq.m.:					0.0507		0.3395	0.2463	0.5858	0.5220	17.79	2.99	20.78

TABLE B-1

B-1

(1) Heating Season: From 1985/01/01 to 1985/12/31
(2) Space Heating System: Individual Gas Furnaces (Forced Warm Air)
(3) Domestic Hot Water System: Individual Gas-Fired Water Heaters
(4) Area Weighted Average Energy Consumption Data:
Electric: Lighting and Miscellaneous: 43.70 kWh/m2/yr
Gas: Space and Water Heating: 0.5220 GJ/m2/yr
(5) Infiltration Rates: All Floors Above Grade: 0.75 Air Changes/hr
Basement: 0.50 Air Changes/hr

COMPLEX #2 - NATURAL GAS HYDRONIC SYSTEM

Project Name: Cooperative Housing Heating Study
Complex #2 - Natural Gas Hydronic (Hot Water) Heating - Actual Case

Unit Type	No. of Units	Floor Area Per Unit		No. of Bed-rooms	Estimated Heat Loss		Estimated Consumption			Actual SH & DHW Energy Cons.	Capital Cost Estimates		
							Space Heating	DHW Heating	SH & DHW Heating		Space Heating	DHW Heating	SH & DHW Heating
		sq.m.	sq.ft.		kW	Btu/h	GJ	GJ	GJ	GJ	$	$	$
A	1	90.9	978	2	4.7	15958	25.2	24.3	49.5	70.5	4160	350	4510
B	6	89.6	964	2	5.3	18233	35.8	24.3	60.1	69.5	4158	350	4508
C	2	89.7	966	2	4.7	15891	25.8	24.3	50.1	69.6	4028	350	4378
D	6	89.7	966	2	4.0	13753	20.1	24.3	44.4	69.6	4028	350	4378
E	19	94.4	1016	3	5.1	17313	27.6	30.3	57.9	73.2	4487	350	4837
F	2	114.5	1232	3	6.3	21397	37.0	30.3	67.3	88.8	4503	350	4853
G	8	114.5	1232	3	5.3	18174	27.7	30.3	58.0	88.8	4503	350	4853
H	2	105.4	1134	3	5.4	18461	35.0	30.3	65.3	81.7	4325	350	4675
J	4	125.0	1346	4	7.5	25557	45.6	36.4	82.0	97.0	4503	350	4853
Gross Totals:	50	4995.0	53766	139	262.6	895939	1484.0	1449.4	2933.4	3874.8	218277	17500	235777
Average Per Unit:		99.9	1075	2.8	5.3	17919	29.7	29.0	58.7	77.5	4366	350	4716
Average Per sq.m.:					0.0526		0.2971	0.2902	0.5873	0.7757	43.70	3.50	47.20

B-2
TABLE B-2

(1) Heating Season: From 1985/01/01 to 1985/12/31
(2) Space Heating System: Individual Boilers (Hydronic)
(3) Domestic Hot Water System: Individual Gas-Fired Water Heaters
(4) Area Weighted Average Energy Consumption Data:
Electric: Lighting and Miscellaneous: 53.18 kWh/m2/yr
Gas: Space and Water Heating: 0.7757 GJ/m2/yr
(5) Infiltration Rates: All floors above grade: 0.75 Air Changes/hr
Basement: 0.50 Air Changes/hr

COMPLEX #3 - ELECTRIC BASEBOARD SYSTEM

Project Name: Cooperative Housing Heating Study
Complex #3 - Electric Baseboard Heating - Actual Case

Unit Type	No. of Units	Floor Area Per Unit		No. of Bed-rooms	Estimated Heat Loss		Estimated Consumption			Actual SH & DHW Energy Cons.	Capital Cost Estimates		
							Space Heating	DHW Heating	SH & DHW Heating		Space Heating	DHW Heating	SH & DHW Heating
		sq.m.	sq.ft.		kW	Btu/h	kW.h	kW.h	kW.h	kW.h	$	$	$
A	6	90.6	975	2	4.2	14448	4609	4062	8671	9389	1119	350	1469
B	10	97.2	1046	3	4.1	13910	4510	5053	9563	10073	1622	350	1972
C	14	97.2	1046	3	4.5	15258	4896	5053	9949	10073	1622	350	1972
F	2	85.7	922	2	3.8	12858	4190	4062	8252	8879	1129	350	1479
Gross Totals:	32	3047.0	32798	88	136.3	465116	149668	153768	303436	315853	47900	11200	59100
Average Per Unit:		95.2	1025	2.8	4.3	14534.9	4677.1	4805.3	9482.4	9870.4	1496.9	350.0	1846.9
Average Per sq.m.:					0.0447		49.12	50.47	99.58	103.66	15.72	3.68	19.40

B-3
TABLE B-3

(1) Heating Season: From 1985/01/01 to 1985/12/31
(2) Space Heating System: Electric Baseboard Heaters
(3) Domestic Hot Water System: Individual Electric Water Heaters
(4) Area Weighted Average Energy Consumption Data:
Electric: Lighting and Miscellaneous: 47.46 kWh/m2/yr
Space and Water Heating: 103.66 kWh/m2/yr
(5) Infiltration Rates: All floors above grade: 0.50 Air Changes/hr
Basement: 0.50 Air Changes/hr

APPENDIX C

B. C. Hydro

Building Energy Analysis System

B. C. HYDRO BUILDING ENERGY ANALYSIS SYSTEM

B. C. Hydro's Building Energy Analysis System (BEAS) was used to assemble customer energy consumption information contained in this report. The program transfers natural gas and electrical consumption data from the billing system and combines it with building and degree day information to produce various types of reports.

Page C-2 is an example of the energy consumption report generated by the BEAS program for each townhouse complex resident involved with this study.

Pages C-3, C-4, and C-5 represent the minimum, maximum, and weighted average energy consumption, expressed in kW.h/m^2 and kW.h/m^2/1000C degree days for all residents within each housing complex.

For the interested user, B. C. Hydro's Commercial Building Data Base is explained on page C-6. A copy of building data input sheet B1490A is also attached.

B C HYDRO BUILDING ENERGY MANAGEMENT PROGRAM PAGE 0001

SUMMARY OF TOTAL ENERGY CONSUMPTION

FOR : [redacted]
VANCOUVER

FROM: 85-01-01 TO 85-12-31

BUILDING FUNCTION: GAS FIRED FURNACE SYSTEM
BUILDING AREA IN SQUARE METRE: 154
OCCUPANTS: 3
EUE IDENTIFICATION NUMBER : 0000558
TOTAL DEGREE DAYS IN ANALYSIS PERIOD: 3342.0
TOTAL NUMBER OF DAYS IN ANALYSIS PERIOD: 365

ENERGY USE IN KWH

ELECTRICITY		6086	22 %
GAS	(760 BILLING UNITS)	21155	78 %
-TOTAL ENERGY USE-		27241	

ENERGY DISTRIBUTION BY APPLICATION

ELECTRIC	LIGHTING & MISC	6086	22 %
GAS	SPACE HEATING WATER HEATING	21155	78 %

UNIT CONSUMPTIONS

KWH/SQUARE METRE		
- SPACE & WATER HEATING	137.37	78 %
- LIGHTING & MISCELLANEOUS	39.52	22 %
- TOTAL ELECTRIC	39.52	22 %
- TOTAL GAS	137.37	78 %
- TOTAL CONSUMPTION	176.89	
KWH/SQUARE METRE/1000 C DEGREE DAY		
- SPACE & WATER HEATING	41.10	78 %
- TOTAL CONSUMPTION	52.93	

C-2

LOCATIONAL AUDIT REPORT

B C HYDRO BUILDING ENERGY MANAGEMENT PROGRAM

DIVISIONAL SUMMARY

FOR : METRO (VANCOUVER CITY ONLY)
GAS HEAT SYSTEM-RESIDENTIAL
GAS FIRED FURNACE SYSTEM

FROM : 85-01-01 TO 85-12-31

UNIT CONSUMPTION	LOW*	MEDIAN*	HIGH*	NO. IN SAMPLE	AREA WEIGHTED AVERAGE**
KWH/SQUARE METRE					
- SPACE AND WATER HEATING	107.98	141.17	191.21	65	145.08
- LIGHTING AND MISCELLANEOUS	26.75	41.89	64.71	65	43.70
- TOTAL ELECTRIC	26.75	41.89	64.71	65	43.70
- TOTAL GAS	107.98	141.17	191.21	65	145.08
- TOTAL CONSUMPTION	142.88	188.12	236.24	65	188.78
KWH/SQUARE METRE/1000 C DEGREE					
- SPACE AND WATER HEATING	32.31	42.24	57.21	65	43.41
- TOTAL CONSUMPTION	42.75	56.29	70.69	65	56.49

- TO DETERMINE BUILDING PERFORMANCE COMPARE ITS UNIT CONSUMPTION (FROM THE INDIVIDUAL LOCATIONAL REPORT) TO THE AREA WEIGHTED AVERAGES. THE LOWER DECILE SHOWS HOW WELL SOME EXISTING BUILDINGS PERFORMED.

- NOTE THAT THE ABOVE INFORMATION IS BASED ON ENERGY CONSUMPTION OF EXISTING BUILDINGS, MOST OF WHICH WERE NOT BUILT WITH ENERGY EFFICIENCY AS A MAJOR CONSIDERATION. OFTEN A REDUCTION OF 15 - 25 % IS PRACTICAL.

- NEW BUILDINGS SHOULD BE DESIGNED TO USE 35 - 75 % LESS ENERGY THAN THE AVERAGE OF EXISTING BUILDINGS OF THE SAME TYPE.

* BY DEFINITION HALF THE BUILDINGS IN THE SAMPLE HAVE CONSUMPTION LESS THAN THAT OF THE MEDIAN BUILDING; THE OTHER HALF HAVE HIGHER CONSUMPTION. 10% OF THE BUILDINGS HAVE CONSUMPTION LESS THAN THE LOW (LOWER DECILE) AND 10% HAVE CONSUMPTION GREATER THAN THE HIGH (UPPER DECILE).

** AREA WEIGHTED AVERAGES = TOTAL CONSUMPTION FOR ALL LOCATIONS DIVIDED BY THEIR TOTAL FLOOR AREA.

DIVISIONAL SUMMARY

FOR : METRO (VANCOUVER CITY ONLY)
GAS HEAT SYSTEM-RESIDENTIAL
GAS FIRED HYDRONIC BASEBOARD SYSTEM

FROM : 85-01-01 TO 85-12-31

UNIT CONSUMPTION	LOW*	MEDIAN*	HIGH*	NO. IN SAMPLE	AREA WEIGHTED AVERAGE**
KWH/SQUARE METRE					
- SPACE AND WATER HEATING	175.47	219.00	270.09	49	215.58
- LIGHTING AND MISCELLANEOUS	35.95	53.85	74.52	49	53.18
- TOTAL ELECTRIC	35.95	52.95	74.52	50	53.17
- TOTAL GAS	175.47	219.00	270.09	50	215.82
- TOTAL CONSUMPTION	216.85	267.22	328.02	50	268.99
KWH/SQUARE METRE/1000 C DEGREE					
- SPACE AND WATER HEATING	52.51	65.53	80.82	49	64.51
- TOTAL CONSUMPTION	64.89	79.96	98.15	50	80.49

- TO DETERMINE BUILDING PERFORMANCE COMPARE ITS UNIT CONSUMPTION (FROM THE INDIVIDUAL LOCATIONAL REPORT) TO THE AREA WEIGHTED AVERAGES. THE LOWER DECILE SHOWS HOW WELL SOME EXISTING BUILDINGS PERFORMED.

- NOTE THAT THE ABOVE INFORMATION IS BASED ON ENERGY CONSUMPTION OF EXISTING BUILDINGS, MOST OF WHICH WERE NOT BUILT WITH ENERGY EFFICIENCY AS A MAJOR CONSIDERATION. OFTEN A REDUCTION OF 15 - 25 % IS PRACTICAL.

- NEW BUILDINGS SHOULD BE DESIGNED TO USE 35 - 75 % LESS ENERGY THAN THE AVERAGE OF EXISTING BUILDINGS OF THE SAME TYPE.

* BY DEFINITION HALF THE BUILDINGS IN THE SAMPLE HAVE CONSUMPTION LESS THAN THAT OF THE MEDIAN BUILDING; THE OTHER HALF HAVE HIGHER CONSUMPTION. 10% OF THE BUILDINGS HAVE CONSUMPTION LESS THAN THE LOW (LOWER DECILE) AND 10% HAVE CONSUMPTION GREATER THAN THE HIGH (UPPER DECILE).

** AREA WEIGHTED AVERAGES = TOTAL CONSUMPTION FOR ALL LOCATIONS DIVIDED BY THEIR TOTAL FLOOR AREA.

NATURAL GAS HYDRONIC SYSTEM

C-4

DIVISIONAL DECILE SUMMARY

DIVISIONAL SUMMARY

FOR : METRO (VANCOUVER CITY ONLY)
ELECT HEAT SYSTEM-RESIDENTIAL
ELECTRIC BASEBOARD SYSTEM

FROM : 85-01-01 TO 85-12-31

UNIT CONSUMPTION	LOW*	MEDIAN*	HIGH*	NO. IN SAMPLE	AREA WEIGHTED AVERAGE**
KWH/SQUARE METRE					
- TOTAL ELECTRIC	101.71	153.27	188.80	59	152.11
- TOTAL CONSUMPTION	101.71	153.27	188.80	59	152.11
KWH/SQUARE METRE/1000 C DEGREE					
- TOTAL CONSUMPTION	30.43	45.86	56.49	59	45.52

- TO DETERMINE BUILDING PERFORMANCE COMPARE ITS UNIT CONSUMPTION (FROM THE INDIVIDUAL LOCATIONAL REPORT) TO THE AREA WEIGHTED AVERAGES. THE LOWER DECILE SHOWS HOW WELL SOME EXISTING BUILDINGS PERFORMED.

- NOTE THAT THE ABOVE INFORMATION IS BASED ON ENERGY CONSUMPTION OF EXISTING BUILDINGS, MOST OF WHICH WERE NOT BUILT WITH ENERGY EFFICIENCY AS A MAJOR CONSIDERATION. OFTEN A REDUCTION OF 15 - 25 % IS PRACTICAL.

- NEW BUILDINGS SHOULD BE DESIGNED TO USE 35 - 75 % LESS ENERGY THAN THE AVERAGE OF EXISTING BUILDINGS OF THE SAME TYPE.

* BY DEFINITION HALF THE BUILDINGS IN THE SAMPLE HAVE CONSUMPTION LESS THAN THAT OF THE MEDIAN BUILDING; THE OTHER HALF HAVE HIGHER CONSUMPTION. 10% OF THE BUILDINGS HAVE CONSUMPTION LESS THAN THE LOW (LOWER DECILE) AND 10% HAVE CONSUMPTION GREATER THAN THE HIGH (UPPER DECILE).

** AREA WEIGHTED AVERAGES = TOTAL CONSUMPTION FOR ALL LOCATIONS DIVIDED BY THEIR TOTAL FLOOR AREA.

ELECTRIC BASEBOARD SYSTEM

C-5

DIVISIONAL DECILE SUMMARY

COMMERCIAL BUILDING DATA BASE

The Commercial Building Data Base Program is one part of an overall package which accumulates energy use data from B. C. Hydro's billing system. This overall program creates an energy use file for each selected account and transfers energy consumption data from the billing system, (CICS) which remains secure. This energy use data will then be accumulated for as long as the account remains active.

The Commercial Building Data Base Program takes this energy consumption data, combines it with building data input from data sheet B 1490A and degree day program data and produces various types of reports. The types of reports currently available are as follows:

1. An individual building report including:

   (a) energy use - total and by fuel type
   (b) maximum kW demand
   (c) minimum power factor
   (d) energy distribution by application
   (e) unit consumptions - total and by application, expressed as per unit area and per unit area per 1000C degree days.

2. A report covering the same unit consumptions for all buildings in a group, showing the minimum, maximum, and area weighted average for the group. Sample size is also included.

   This report is available as an alternative, showing the median and upper and lower deciles of the unit consumptions.

3. A comparative energy consumption report which compares an individual building normalized energy consumption to a regional group mean normalized energy consumption.

A "group" can be almost anything the user wants it to be. Typically, it would be all highrise office buildings, all hotels, all restaurants, etc. However, these can be combined for a report to summarize all hotels plus all motels, for example. In addition, the grouping can be by geographical region - e.g. all buildings in the Fraser Valley Region.

The capabilities are presently being expanded to include a trend analysis and a ranking of buildings according to energy intensity.

Future modifications include providing additional flexibility in normalization parameters. At present, consumptions are normalized according to floor area and degree days. There is a potential for using up to four individually selected parameters which could include such things as number of persons, number of rooms, units of product, etc. This flexibility will allow some degree of tailoring of reports for energy use studies and will make the project more useful for industrial plants in particular.

APPENDIX D

B. C. Hydro

Residential Energy Advice Program H10

B. C. HYDRO RESIDENTIAL ENERGY ADVICE PROGRAM H10

B. C. Hydro's Residential Energy Advice Program H10 was used to calculate the "estimated" space heating and domestic water heating data used throughout the report. This versatile program can also provide advice and recommendations on heating equipment sizing, annual heating costs, insulation levels, and fuel conversion.

Pages D-2 and D-3 are examples of the program output generated for each different type of townhouse unit.

Pages D-4 through D-8 illustrate a variety of the Residential Energy Advice Program's other capabilities, depending upon the individual customer's needs. Also included in this appendix is a selection of the following B. C. Hydro data sheets:

H10:	B. C. Hydro Residential Energy Advice Questionnaire
H101:	Building Heat Loss Calculations
H336:	Energy Cost Estimates for Natural Gas, Oil, Propane and Electric Residential Water Heating
H338B:	Comparative Energy Costs for Natural Gas, Oil, Propane and Electric Residential Heating

Data Sneet H101 outlines the general procedure and calculations used by Energy Advice Program H10 in performing heat loss calculations.

SPACE HEATING EQUIPMENT SIZING PROGRAM
PRINTOUT OF GENERAL INPUT DATA ON QUESTIONAIRE

LOCATION:
NAME: [redacted] PHONE:
ADDRESS:
Vancouver bc

YEAR OF CONSTRUCTION: 1982
RECORDED ANNUAL OIL CONSUMPTION:
Litres: Gallons: Cost:
HEATING FUEL TO BE USED FOR:
Space heating: 1 = Natural Gas
Domestic water heating: 1 = Natural Gas
Suplementary heating: 0 = None
THERMOSTAT SETTING FOR:
Daytime: 72 Evening: 72 Night-time: 72
STANDARD CELSIUS DEGREE DAYS: 3031 CUSTOMER CELSIUS DEGREE DAYS: 3474
UNHEATED AREA OF HOME
AREA: 0.00 sq.ft. U-VALUE: 0.0000 CELSIUS DEG.-DAYS: 1130
DESIGN TEMPERATURE DIFFERENCE: 52 F
HEATING EQUIPMENT TYPE: 4 = Comparative Analysis of Systems

AIR-TO-AIR HEAT EXCHANGER: N EFFICIENCY: %

HEAT LOSS PROGRAM-RESULTS

STRUCTURAL COMPONENT	AREA(SQ FT)	U-VALUE	HEAT LOSS (Btu/h)
1) Ceiling	556	0.0327	950
2) Roof	0	0.0000	0
3) Above grade wall	1349	0.0610	4295
4) Below grade wall	320	0.0312	522
5) Exposed floors	180	0.0450	423
6) Windows	166	0.7000	6066
7) A/G wall with B/G construction	80	0.0750	313
8) Exterior doors	42	0.1400	307
9) Slab on grade floors	0	0.0000	0
10) Floor over crawl space	0	0.0000	0
11) Skylights	20	0.7800	814
12) Basement floor	396	0.0443	917
13) Common walls between units	315	0.0000	0
TOTAL ENVELOPE	3424	0.0817	14607
14) Infiltration (Non-Electric)		AC/Hr	
A) All floors above grade	1122	0.7500	6325
B) Basement	396	0.5000	1488
Total			22420

The information herein is only for guidance. B.C. Hydro is not responsible for installations. Installations are the responsibility of the installer and they should meet the current requirements of the owner, manufacturer's instructions and applicable regulations.

1-April-1986
Residential and Commercial Energy Management

09:32 FY5
B.C. Hydro

EQUIPMENT SIZING AND SPACE HEATING ENERGY CONSUMPTION ESTIMATION

For the home of: [redacted]
Vancouver bc

Location	# of Persons	Style	# of Floors	Roof	Basement	Flr Area	Heating Fuel	Yr Built
Vancouver	3	Semi-Det	Two	Pitched	Heated	1518 ft^2	Natural Gas	1982

B.C. Hydro thanks you for completing the questionnaire. Based on the supplied information, the following table shows the estimated equipment capacity and annual heating cost for various heating systems.

Space Heating System	Estimated Minimum Input Capacity[1]	Estimated Annual Space Heating Consumption[2]	Estimated Annual Space Heating Cost[3]
Space Heating			
Conventional Forced Warm Air (FWA) Furnace	28000 Btu/h	40.4 GJ	$230
Intermediate Efficiency FWA Furnace	27000 Btu/h	32.9 GJ	$200
High Efficiency FWA Furnace	24400 Btu/h	29.2 GJ	$180
Conventional Hydronic Boiler	32200 Btu/h	40.4 GJ	$230
Intermediate Efficiency Hydronic Boiler	29600 Btu/h	30.9 GJ	$190
Domestic Water Heating			
Conventional Domestic Water Heater (DWH)	33.3 Imperial Gallons	27.4 GJ	$120
Conventional Energy Efficient DWH	33.3 Imperial Gallons	24.9 GJ	$110
Intermediate Efficiency DWH	33.3 Imperial Gallons	22.8 GJ	$100

1. Sizing for space heating is based on maintaining an indoor space temperature of 22°C (72°F).
2. Estimated annual space heating consumption is based on maint aining an indoor space temperature of 21°C (70°F) for 24 hours/day. The indoor space temperature settings supplied by you would increase the estimated consumption by 15%. Actual consumption will vary with individual living habits.
3. Heating cost is based on an energy rate of $4.34 per gigajoule.

Additional Recommendations:

- Intermediate or High Efficiency space heating equipment and Conventional Energy Efficient domestic water heater are recommended.
- Your contractor should size the space heating equipment based on your actual house dimensions and construction. For comfort and economy, avoid oversizing.
- For central space heating systems, automatic temperature set-back thermostats are recommended.

For more information, please contact your nearest B.C. Hydro Office

The information herein is only for guidance. B.C. Hydro is not responsible for installations. Installations are the responsibility of the installer and they should meet the current requirements of the owner, manufacturer's instructions and applicable regulations.

1-April-1986
Residential and Commercial Energy Management B.C. Hydro

EQUIPMENT SIZING AND HEATING ENERGY CONSUMPTION ESTIMATION

For the home of: I.M. Demo - New Home
123 Some Street
Vancouver
H0H 0H0

Location	# of People	Style	# of Floors	Roof	Basement	Floor Area	Heating Fuel	Year Built
Vancouver	5	Detached	Split Level	Pitched	Heated	1950 sq.ft.	Natural Gas	1986

B.C. Hydro thanks you for completing the questionnaire.

Based on the supplied information, the following table shows the estimated equipment capacity and annual heating cost for various heating systems.

EQUIPMENT TYPE	EST. MIN. CAPACITY[1]	ESTIMATED ANNUAL HEATING	
		CONSUMPTION[2]	COST[3]
Space Heating			
Conventional Forced Warm Air (FWA) Furnace	51700 Btu/h	73.3 GJ	$375
Intermediate Efficiency FWA Furnace	49800 Btu/h	59.6 GJ	$315
High Eff. FWA Furnace	44900 Btu/h	52.9 GJ	$285
Conventional Hydronic Boiler	59400 Btu/h	73.3 GJ	$375
Intermediate Efficiency Hydronic Boiler	54700 Btu/h	56.0 GJ	$300
Domestic Water Heating			
Conventional Domestic Water Heater (DWH)	33.3 Imp. Gals.	37.5 GJ	$165
Conventional Energy Efficient DWH	33.3 Imp. Gals.	34.1 GJ	$150
Intermediate Efficiency DWH	33.3 Imp. Gals.	31.2 GJ	$135

1. Sizing for space heating is based on maintaining an indoor space temperature of 22°C (72°F).
2. Estimated annual space heating consumption is based on maintaining an indoor space temperature of 21°C (70°F) for 24 hr/day. The indoor space temperature settings supplied by you would decrease the estimated consumption by 5%. Actual consumption will vary with individual living habits.
3. Heating cost is based on an energy rate of 4.34 $/GJ.

Additional Recommendations

- Intermediate or High Efficiency space heating equipment and Conventional Energy Efficient domestic water heater are recommended.
- Your contractor should size the space heating equipment based on your actual house dimensions and construction. For comfort and economy, avoid oversizing.
- For central space heating systems, automatic temperature set-back thermostats are recommended.

For more information, please contact your nearest B.C. Hydro office.

The information herein is only for guidance. B.C. Hydro is not responsible for installations. Installations are the responsibilty of the installer and they should meet the current requirements of the owner, manufacturer's instructions and applicable regulations.

17-Jan-86:TKWL/GJ
Residential and Commercial Energy Management B.C. Hydro

CONVERSION FROM OIL TO NATURAL GAS HEATING ADVICE

For the home of: I.M. Demo
123 Some Street
Vancouver
H0H 0H0

Location	# of People	Style	# of Floors	Roof	Basement	Floor Area	Heating Fuel	Year Built
Vancouver	5	Detached	Split Level	Pitched	Heated	1950 sq.ft.	Natural Gas	1977

B.C. Hydro thanks you for completing the questionnaire.

Based on the supplied information, the following table shows the estimated savings, installed cost and payback for converting to various gas heating systems. Please note that the installed costs are approximate and only for your guidance.

Based on Your Supplied Oil Consumption for Space and Domestic Water Heating of 878 Imperial gallons ($1500)

Annual Oil Cost		Equivalent Natural Gas Cost[1]	Estimated 1st Year Saving[1]	Payback
Allowance for Domestic Water Heating	= $360	$150	$210	2.0 years
Net Space Heating Consumption	= $1140	$460	$680	2.9 years

1. Estimate based on your recorded oil consumption and assuming Intermediate Efficiency Forced Warm Air Furnace and Conventional Energy Efficient Domestic Water Heater.

Due to the difficulties in obtaining an accurate annual oil consumption, the following table is based on our typical consumption for a home similar to yours and has been included here for your information.

Based on Our Typical Oil Consumption for Space Heating and Domestic Water Heating of 940 Imperial gallons ($1605)[1]

Gas Heating System Type	Estimated Minimum Input Capacity	Estimated 1st Year Gas Cost	Potential 1st Year Saving	Estimated Equipment Installed Cost	Payback
Space Heating					
Conventional Forced Warm Air (FWA) Furnace	64800 Btu/h	$600	$645	$1570	2.4 years
Intermediate Efficiency FWA Furnace	62500 Btu/h	$495	$750	$2025	2.6 years
High Efficiency FWA Furnace	56400 Btu/h	$445	$800	$3255	3.9 years
Domestic Water Heating					
Conventional Domestic Water Heater (DWH)	33.3 Imp. Gals.	$165	$195	$400	2.0 years
Conventional Energy Efficient DWH	33.3 Imp. Gals.	$150	$210	$430	2.0 years
Intermediate Efficiency DWH	33.3 Imp. Gals.	$135	$225	$850	3.6 years

1. Estimated space heating consumption is based on the indoor space temperature settings supplied by you (70°F daytime, 70°F evening, and 68°F night-time). Maintaining an indoor space temperature of 21°C (70°F) for 24 hr/day would increase consumption by 5%. Actual consumption will vary with individual living habits.

Additional Recommendations:
- Intermediate or High Efficiency space heating equipment and Conventional Energy Efficient domestic water heater are recommended.
- Before converting, consult with your heating contractors and obtain more than one estimate.
- Your contractor should size the space heating system based on your actual house dimensions and construction. For comfort and economy, avoid oversizing.
- Improving the insulation level of your home before converting will add to the comfort of your home and lower the initial conversion costs.

For more information, call B.C. Hydro **GAS HEAT LINE: 298-2411.** ***GO GAS & SAVE!!!***

The information herein is only for guidance. B.C. Hydro is not responsible for installations. Installations are the responsibilty of the installer and they should meet the current requirements of the owner, manufacturer's instructions and applicable regulations.

17-Jan-86: TKWL/GJ
Residential and Commercial Energy Management **B.C. Hydro**

OPTIMUM INSULATION ADVICE FOR EXISTING HOMES

For the home of: I.M. Demo
123 Some Street
Vancouver
HOH OHO

Location	# of People	Style	# of Floors	Roof	Basement	Floor Area	Heating Fuel	Year Built
Vancouver	5	Detached	Split Level	Pitched	Heated	1950 sq.ft.	Natural Gas	1977

B.C. Hydro thanks you for completing the questionnaire.

The following table gives estimated savings from insulating to B.C. Hydro's recommendations. Estimated savings are based on current fuel prices and are approximate. Actual savings will depend on your living habits and how well the insulation is applied. Insulation costs are only for your guidance. Should you decide to use a contractor, you are advised to get more than one estimate.

Element	Area[1]	Present Condition	Recommended Retrofit	Potential 1st Year Savings[2]	Contract Out Cost	Contract Out Payback	Do It Yourself Cost	Do It Yourself Payback
Ceiling	1330 sq.ft.	R 20	Add R 20 To Your Attic	$ 50	$ 930	15.9 yr	$ 530	9.6 yr
Roof	20 sq.ft.	R 12	Not Economical to Retrofit Unless Reroofing					
Walls[3]	1427 sq.ft.	R 12	Your insulation is adequate					
Windows[4]	350 sq.ft.	Metal, single glazed	Add storm windows	$ 250	$2450	9.0 yr	$1750	6.5 yr
			Replace with double glazed	$ 250	$3500	12.4 yr	$2800	10.1 yr
			Add double glazed	$ 310	$3500	10.2 yr	$2800	8.3 yr
			Replace with triple glazed	$ 310	$5110	14.3 yr	$4060	11.7 yr
			Add triple glazed	$ 335	$5110	13.4 yr	$4060	10.9 yr
			Replace with quad. glazed	$ 335	$6035	15.5 yr	$4635	12.3 yr

1. If the actual areas differ from those assumed, prorate the savings and costs. The payback period will remain the same.
2. Savings are based on Conventional Forced Warm Air Furnace and the indoor space temperature settings supplied by you.
3. Only the above grade walls are considered for retrofit.
4. Calculated savings are based on windows with a 1/2 inch (12mm) air space and a thermal break.

Other Energy Conserving Tips:
- Save at no cost by lowering thermostats settings at night. Consider purchasing an electronic thermostat for automatic night set-back.
- Weatherstrip and caulk doors and window frames to reduce drafts and save.

****
* You may be eligible for Federal grants up to $500 to insulate your home. *
* For details phone 686-2717 (outside Vancouver call 1-800-663-9529). *
****
* B.C.Hydro provides loans of up to $750 at 12.5% for approved customers. *
* You have up to two years to repay. Windows are included in financing. *
****

For more information, please contact your nearest B.C. Hydro office.

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17-Jan-86:TKWL/GJ
Residential and Commercial Energy Management B.C. Hydro

CONVERSION FROM OIL TO ELECTRIC HEATING ADVICE

For the home of: I.M. Demo
123 Some Street
Vancouver
H0H 0H0

Location	# of People	Style	# of Floors	Roof	Basement	Floor Area	Heating Fuel	Year Built
Vancouver	5	Detached	Split Level	Pitched	Heated	1950 sq.ft.	Electricity	1977

B.C. Hydro thanks you for completing the questionnaire.

Based on the supplied information, the following table shows the estimated savings, installed cost and payback for converting to various electric heating systems. Please note that the installed costs are approximate and only for your guidance.

Based on Your Supplied Oil Consumption for Space and Domestic Water Heating of 877 Imperial gallons ($1500)

Annual Oil Cost		Equivalent Electric Cost[1]	Estimated 1st Year Saving[1]	Payback With No Upgrade of Electrical Panel	Payback With Upgrade of Electrical Panel
Allowance for Domestic Water Heating	= $360	$270	$90	4.4 years	N/A
Net Space Heating Consumption	= $1140	$925	$215	6.9 years	9.3 years

1. Estimate based on your recorded oil consumption and assuming Forced Warm Air Furnace and Energy Efficient Domestic Water Heater.

Due to the difficulties in obtaining an accurate annual oil consumption, the following table is based on our typical consumption for a home similar to yours and has been included here for your information.

Based on Our Typical Oil Consumption for Space Heating and Domestic Water Heating of 940 Imperial gallons ($1605)[1]

Electric Heating System Type	Estimated Minimum Input Capacity	Estimated 1st year Electric Cost	Potential 1st year Saving	No Upgrade of Elec. Panel: Installed Cost	No Upgrade of Elec. Panel: Payback	With Upgrade of Elec. Panel: Installed Cost	With Upgrade of Elec. Panel: Payback
Space Heating							
Baseboard Heater	18 kW	$885	$360	$2880	7.4 years	$3480	8.8 years
Radiant Panels	18 kW	$885	$360	$3960	10.0 years	$4560	11.3 years
Central Forced Warm Air	16 kW	$940	$305	$1600	5.0 years	$2200	6.7 years
Heat Pump	4.0 Tons 16 kW	$515	$730	$4600	5.9 years	$5200	6.6 years
Add-on Electric Plenum Heater[2]	12 kW	$1035	$210	$1500	6.7 years	N/A	N/A
Add-on Heat Pump[2]	4.0 Tons	$660	$585	$3700	5.9 years	N/A	N/A
Hydronic Central Boiler	18 kW	$940	$305	$2700	8.1 years	$3300	9.8 years
Domestic Water Heating							
Energy Eff. Dom. Water Heater	60.0 Imp. Gals.	$270	$90	$420	4.4 years	N/A	N/A

1. Estimated space heating consumption is based on the indoor space temperature settings supplied by you (70°F daytime, 70°F evening, and 68°F night-time). Maintaining an indoor space temperature of 21°C (70°F) for 24 hr/day would increase consumption by 5%. Actual consumption will vary with individual living habits.
2. For add-on dual fuel systems, an average oil displacement of 75% is assumed.

Additional Recommendations:

- Before converting, obtain more than one cost estimate and consult with your heating contractors regarding the requirement for an electric panel upgrade.
- Your contractor should size the space heating equipment based on your actual house dimensions and construction. For comfort and economy, avoid oversizing.
- Improving the insulation level of your home before converting will add to the comfort of your home and lower the initial conversion costs.

For more information, please contact your nearest B.C. Hydro office.

The information herein is only for guidance. B.C. Hydro is not responsible for installations. Installations are the responsibilty of the installer and they should meet the current requirements of the owner, manufacturer's instructions and applicable regulations.

17-Jan-86:TKWL/GJ
Residential and Commercial Energy Management B.C. Hydro

CONVERSION FROM PROPANE TO ELECTRIC HEATING ADVICE

For the home of: I.M. Demo
123 Some Street
Vancouver
H0H 0H0

Location	# of People	Style	# of Floors	Roof	Basement	Floor Area	Heating Fuel	Year Built
Vancouver	5	Detached	Split Level	Pitched	Heated	1950 sq.ft.	Electricity	1977

B.C. Hydro thanks you for completing the questionnaire.

Based on the supplied information, the following table shows the estimated savings, installed cost and payback for converting to various electric heating systems. Please note that the installed costs are approximate and only for your guidance.

Based on Your Supplied Propane Consumption for Space and Domestic Water Heating of 1100 Imperial gallons ($1500)

Annual Propane Cost	Equivalent Electric Cost[1]	Estimated 1st Year Saving[1]	Payback With No Upgrade of Electrical Panel	Payback With Upgrade of Electrical Panel
Allowance for Domestic Water Heating = $440	$270	$170	2.4 years	N/A
Net Space Heating Consumption = $1060	$730	$330	4.6 years	6.2 years

1. Estimate based on your recorded propane consumption and assuming Forced Warm Air Furnace and Energy Efficient Domestic Water Heater.

Due to the difficulties in obtaining an accurate annual propane consumption, the following table is based on our typical consumption for a home similar to yours and has been included here for your information.

Based on Our Typical Propane Consumption for Space Heating and Domestic Water Heating of 1400 Imperial gallons ($1910)[1]

Electric Heating System Type	Estimated Minimum Input Capacity	Estimated 1st year Electric Cost	Potential 1st year Saving	No Upgrade of Elec. Panel: Installed Cost	No Upgrade of Elec. Panel: Payback	With Upgrade of Elec. Panel: Installed Cost	With Upgrade of Elec. Panel: Payback
Space Heating							
Baseboard Heater	18 kW	$885	$585	$2880	4.7 years	$3480	5.6 years
Radiant Panels	18 kW	$885	$585	$3960	6.3 years	$4560	7.2 years
Central Forced Warm Air	16 kW	$940	$530	$1600	2.9 years	$2200	4.0 years
Heat Pump	4.0 Tons 16 kW	$515	$955	$4600	4.6 years	$5200	5.1 years
Hydronic Central Boiler	18 kW	$940	$530	$2700	4.8 years	$3300	5.9 years
Domestic Water Heating							
Energy Eff. Dom. Water Heater	60.0 Imp. Gals.	$270	$170	$420	2.4 years	N/A	N/A

1. Estimated space heating consumption is based on the indoor space temperature settings supplied by you (70°F daytime, 70°F evening, and 68°F night-time). Maintaining an indoor space temperature of 21°C (70°F) for 24 hr/day would increase consumption by 5%. Actual consumption will vary with individual living habits.

Additional Recommendations:

- Before converting, obtain more than one cost estimate and consult with your heating contractors regarding the requirement for an electric panel upgrade.
- Your contractor should size the space heating equipment based on your actual house dimensions and construction. For comfort and economy, avoid oversizing.
- Improving the insulation level of your home before converting will add to the comfort of your home and lower the initial conversion costs.

For more information, please contact your nearest B.C. Hydro office.

The information herein is only for guidance. B.C. Hydro is not responsible for installations. Installations are the responsibilty of the installer and they should meet the current requirements of the owner, manufacturer's instructions and applicable regulations.

17-Jan-86: TKWL/GJ
Residential and Commercial Energy Management B.C. Hydro

APPENDIX E

B. C. Hydro

Residential Energy Rates

B. C. HYDRO RESIDENTIAL ENERGY RATES

1. ELECTRIC TARIFF:

Residential Service

Rate: For a period of two months:

Schedule 1101 - Residential Service

Basic Charge $6.52 per period

First 550 kW.h per period @ 6.42¢ per kW.h
All additional kW.h per period @ 4.47¢ per kW.h.

2. GAS TARIFF:

General Service

Rate: For a period of two months:

Basic Charge $9.28 per period

All gigajoules per period at $4.34 per gigajoule.

APPENDIX F

Life Cycle Costing

LIFE CYCLE COSTING

General Application

Life Cycle Costing is a type of broad economic analysis used to compare alternate systems having different initial and long-term operating costs. It is a method of expenditure evaluation which takes into account all costs associated with the expenditure during the time the system is in use, such as initial costs, interest, energy costs, operating expenses, and cost escalation. This comprehensive technique therefore offers much more meaningful results than a review of capital or operating costs alone.

The Life Cycle Costing approach can be greatly influenced by varying the initial economic assumptions.

Table 5 on page 10 of the Procedure and Results section is based on the following assumptions:

- Life of Project = 25 years
- Borrowing Rate = 10%
- Interest Rate = 9%
- Inflation Rate = 5%
- Fuel Escalation Rate = 6%
- Equipment Service Life = 25 years
- Equipment Salvage Value = 5%
- Typical 102.2 m^2 Townhouse
- All costing in 1986 dollars
- Current B. C. Hydro residential energy rates
- Equipment maintenance cost/25 years:
    - Gas Furnace: $ 200
    - Gas Boiler: $1000
    - Electric Baseboard: $ 70

Effect of Equipment Service Life

Table 5 assumes an equal equipment service life of 25 years for all three systems investigated in this report. However, information sources differ on this subject.

In an attempt to determine the effects of varying equipment service life, two additional analyses were performed, using both actual and estimated energy consumption rates:

(A) ACTUAL ENERGY CONSUMPTION RATES:

Complex Number	Heating System	Equipment Life Years (1)	Life Cycle Costing $/25 Yr	Relative Life Cycle Costing	Equipment Life Years (2)	Life Cycle Costing $/25 Yr	Relative Life Cycle Costing	Equipment Life Years(3)	Life Cycle Costing $/25 Yr	Relative Life Cycle Costing
1	Gas Furnaces	25	6,800	100	18	7,600	100	25	6,800	100
2	Gas Boilers	15	14,300	210	24	12,400	163	25	12,000	176
3	Electric Baseboard	25	9,900	146	25	9,900	130	25	9,900	146

(B) ESTIMATED ENERGY CONSUMPTION RATES:

1	Gas Furnaces	25	7,300	100	18	8,000	100	25	7,300	100
2	Gas Boilers	15	13,000	178	24	12,000	150	25	10,600	145
3	Electric Baseboard	25	9,600	132	25	9,600	120	25	9,600	132

Table F-1

Sources of Equipment Service Life data:

(1) B. C. Hydro experience
(2) ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers) 1980 Systems Handbook
(3) Equal Service Life Assumption

COMPARISON OF RESULTS:

Heating System	"Best" LCC*	"Worst" LCC	Conclusion
Natural Gas Furnace	100	100	Cheapest to own and operate.
Natural Gas Hydronic	145	210	45% to 110% more expensive than F.W.A.
Electric Baseboard	120	146	20% to 46% more expensive than F.W.A.

* LCC = Life Cycle Costing, $/25 yr.

Table F-2

Effect of Varying Interest and Fuel Escalation Rates

Life cycle costs for the forced warm air, hydronic and electric baseboard heating systems as presented in Table 5, Page 10, and the preceding Table F-1 were calculated based upon fixed borrowing, interest, and fuel escalation rates.

As a means of examining the sensitivity of the costing analysis to these parameters, fuel escalation rates were increased in stages from 5% to 20% at two fixed borrowing and interest rates. All other variables listed on page F-1 remained unchanged.

A brief summary of the results is tabulated as follows:

(A) ACTUAL ENERGY CONSUMPTION RATES: - Variable Fuel Escalation Rates
- 10% Borrowing Rate
- 9% Interest Rate

	Annual Fuel Escalation Rate	5%		14%		15%		20%	
Complex Number	Heating System	LCC	RLCC*	LCC	RLCC	LCC	RLCC	LCC	RLCC
1	Gas Furnace	6,366	100	14,020	100	15,677	100	29,102	100
2	Gas Boiler	11,364	179	22,032	157	24,342	155	43,052	148
3	Electric Baseboard	9,144	144	21,786	155	24,523	156	46,695	160

*RLCC = Relative Life Cycle Costing

(B) ESTIMATED ENERGY CONSUMPTION RATES: - Variable Fuel Escalation Rates
- 10% Borrowing Rate
- 9% Interest Rate

	Annual Fuel Escalation Rate	5%		7%		9%		20%	
Complex Number	Heating System	LCC	RLCC*	LCC	RLCC	LCC	RLCC	LCC	RLCC
1	Gas Furnace	6,784	100	7,847	100	10,123	100	31,818	100
2	Gas Boiler	10,151	150	11,214	143	13,489	133	35,185	111
3	Electric Baseboard	8,870	131	10,401	133	13,677	135	44,915	141

Table F-3

(A) ACTUAL ENERGY CONSUMPTION RATES: - Variable Fuel Escalation Rates
- 12% Borrowing Rate
- 11% Interest Rate

	Annual Fuel Escalation Rate	5%		15%		17%		20%	
Complex Number	Heating System	LCC	RLCC	LCC	RLCC	LCC	RLCC	LCC	RLCC
1	Gas Furnace	5,670	100	12,525	100	15,519	100	22,075	100
2	Gas Boiler	10,394	183	19,948	159	24,121	155	33,259	151
3	Electric Baseboard	7,995	141	19,316	154	24,261	156	35,089	159

(B) ESTIMATED ENERGY CONSUMPTION RATES: - Variable Fuel Escalation Rates
- 12% Borrowing Rate
- 11% Interest Rate

	Annual Fuel Escalation Rate	5%		9%		12%		20%	
Complex Number	Heating System	LCC	RLCC	LCC	RLCC	LCC	RLCC	LCC	RLCC
1	Gas Furnace	6,018	100	7,880	100	10,123	100	24,081	100
2	Gas Boiler	9,385	156	11,247	143	13,489	133	27,448	114
3	Electric Baseboard	7,767	129	10,448	133	13,677	135	33,775	140

Table F-4

Explanation of Results

When the annual fuel escalation rate increases, operating costs became more influential until a point is reached at which the natural gas hydronic system is cheaper to own and operate than the electric baseboard system. This reversal occurs at the following rates:

Table F-3(A) = between 14% and 15%
Table F-3(B) = between 7% and 9%
Table F-4(A) = between 15% and 17%
Table F-4(B) = between 9% and 12%

As interest and borrowing rates increase at a constant fuel escalation rate, life cycle costs decrease in favor of the lower-capital-cost natural gas furnace system.

APPENDIX G

Effect of Insulation

Effect of Insulation

Insulation levels for townhouse Complexes #1, #2 and #3 are listed in Table 1, page 5, and Table A-1 of Appendix A. Since Complex #1 had the highest insulation levels and also the lowest fuel consumption rate, an investigation was made to determine how well the natural gas hydronic and electric baseboard heating systems would have performed had they been installed in comparably-insulated buildings.

This was done by using B. C. Hydro's Residential Energy Advice Program H10 (refer to Appendix D) to calculate new estimated heat loss and energy consumption data for the "re-insulated" cases. "Modified actual" energy consumption (EC) rates as outlined in Table 6, page 11 were then derived using the following formula:

$$\text{Modified actual EC} = \text{Actual EC} \left[\frac{\text{Estimated EC @ Complex \#1 insulation level}}{\text{Estimated EC @ original insulation level}} \right]$$

Tables G-1 and G-2 contain results for the "reinsulated" complexes.

NATURAL GAS HYDRONIC SYSTEM

COMPLEX #2 REINSULATED TO COMPLEX #1 STANDARDS

Project Name: Cooperative Housing Heating Study
Complex #2 - Natural Gas Hydronic (Hot Water) Heating - Hypothetical Case

Unit Type	No. of Units	Floor Area Per Unit		No. of Bed-rooms	Estimated Heat Loss		Estimated Consumption			Actual SH & DHW Energy Cons.	Capital Cost Estimates		
							Space Heating	DHW Heating	SH & DHW Heating		Space Heating	DHW Heating	SH & DHW Heating
		sq.m.	sq.ft.		kW	Btu/h	GJ	GJ	GJ	GJ	$	$	$
A	1	90.9	978	2	4.1	14087	24.0	24.3	48.3	70.5	4160	350	4510
B	6	89.6	964	2	4.7	15923	28.4	24.3	52.7	69.5	4158	350	4508
C	2	89.7	966	2	4.0	13534	23.0	24.3	47.3	69.6	4028	350	4378
D	6	89.7	966	2	3.5	12086	20.6	24.3	44.9	69.6	4028	350	4378
E	19	94.4	1016	3	4.5	15334	26.5	30.3	56.8	73.2	4487	350	4837
F	2	114.5	1232	3	5.4	18453	35.0	30.3	65.3	88.8	4503	350	4853
G	8	114.5	1232	3	4.8	16268	31.3	30.3	61.6	88.8	4503	350	4853
H	2	105.4	1134	3	4.6	15553	27.3	30.3	57.6	81.7	4325	350	4675
J	4	125.0	1346	4	6.4	21819	41.0	36.4	77.4	97.0	4503	350	4853
Gross Totals:	50	4995.0	53766	139	230.4	785987	1406.5	1449.4	2855.9	3874.8	218277	17500	235777
Average Per Unit:		99.9	1075	2.8	4.6	15720	28.1	29.0	57.1	77.5	4366	350	4716
Average Per sq.m.:					0.0461		0.2816	0.2902	0.5718	0.7757	43.70	3.50	47.20

G-2
TABLE G-1

(1) Heating Season: From 1985/01/01 to 1985/12/31
(2) Space Heating System: Individual Boilers (Hydronic)
(3) Domestic Hot Water System: Individual Gas-Fired Water Heaters
(4) Area Weighted Average Energy Consumption Data:
Electric: Lighting and Miscellaneous: 53.18 kWh/m2/yr
Gas: Space and Water Heating: 0.7757 GJ/m2/yr
(5) Infiltration Rates: All forms above grade: 0.75 Air Changes/hr
Basement: 0.50 Air Changes/hr
(6) Insulation upgraded to Complex #1 insulation levels

ELECTRIC BASEBOARD SYSTEM

COMPLEX #3 REINSULATED TO COMPLEX #1 STANDARDS

Project Name: Cooperative Housing Heating Study
Complex #3 - Electric Baseboard Heating - Hypothetical Case

Unit Type	No. of Units	Floor Area Per Unit		No. of Bed-rooms	Estimated Heat Loss		Estimated Consumption			Actual SH & DHW Energy Cons.	Capital Cost Estimates		
							Space Heating	DHW Heating	SH & DHW Heating		Space Heating	DHW Heating	SH & DHW Heating
		sq.m.	sq.ft.		kW	Btu/h	kW.h	kW.h	kW.h	kW.h	$	$	$
A	6	90.6	975	2	4.2	14420	4598	4062	8660	9389	1119	350	1469
B	10	97.2	1046	3	4.1	13884	4499	5053	9552	10073	1622	350	1972
C	14	97.2	1046	3	4.5	15232	4885	5053	9938	10073	1622	350	1972
F	2	85.7	922	2	3.7	12726	4091	4062	8153	8879	1129	350	1479
Gross Totals:	32	3047.0	32798	88	136.0	464060	149139	153768	302907	315853	47900	11200	59100
Average Per Unit:		95.2	1024.9	2.8	4.3	14501.9	4660.6	4805.3	9465.8	9870.4	1496.9	350.0	1846.9
Average Per sq.m.:					0.0446		48.95	50.47	99.41	103.66	15.72	3.68	19.40

TABLE G-2 G-3

(1) Heating Season: From 1985/01/01 to 1985/12/31
(2) Space Heating System: Electric Baseboard Heaters
(3) Domestic Hot Water System: Individual Electric Water Heaters
(4) Area Weighted Average Energy Consumption Data:
Electric: Lighting and Miscellaneous: 47.46 kWh/m2/yr
Space and Water Heating: 103.66 kWh/m2/yr
(5) Infiltration Rates: All floors above grade: 0.50 Air Changes/hr
Basement: 0.50 Air Changes/hr
(6) Insulation upgraded to Complex #1 insulation levels